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Modification of Brazilian Curaua Fibre Properties

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***Abstract* – Natural fibres extracted from plant bast and other parts are talented resources to the engineering polymers. Especially plant fibres extracted from amazon base are precious with cellulosic resulting stronger to bear mechanical loading. However vegetable fibres are naturally coated with wax and other deposits to protect from environmental attacks and swelling. Hence vegetable fibres need pre-processing before being impregnated into the polymer system. Mercerization is one of the well-known surface treatment method to activate vegetable fibre surface to create stronger bonding with the polymer matrix.**
Natural fibre was treated with silane solutions of different concentrations. This silanation process influences surface morphology and mechanical properties of natural fibre. This work is part of a research about the development of hybrid composites with Curaua fibers.

Key Words: Curaua fibre, Silane treatment, Mercerization, FT-IR, Optical Microscopy

INTRODUCTION

A natural fibre is an agglomeration of cells in which the diameter is negligible in comparison with the length. A natural fibre is extracted form pineapple leaf and it is known as curaua fibre, originating from the Brazilian Amazon, has become prominent for its mechanical performance in relation to other vegetal fibers. Curaua fibre is of low cost, non-abrasive, easy processing, non-toxic, biodegradable and having low density with high mechanical properties. Regarding environmental aspects, the closed CO_2 cycle avoids the increase in greenhouse effect and reuse of agricultural residues reduce their accumulation in the environment.
Curaua fibre is highly humidity absorbing fibre because of its hydrophilic nature, which can cause swelling of fibre and can influence dimensional stability. To overcome this drawback silane treatment on Curaua fibre is done. Therefore, Natural fibres should be modified by surface treatments to improve thermodynamic miscibility and interface bonding strength prior to be applied in polymer composites as reinforcement materials. Silane treatment is one of the important surface treatments and is commonly used for the natural fibre modification, which can improve dispersion stability. Silane act as coupling agent as well as change in the micro structure of Curaua fibre. The change can be observed by FTIR technique.
Moreover, silane treatment is different from other chemical modification methods because silane coupling agents could interact with both matrix and hydrophilic fibre, respectively, and then promote to form a bridge of chemical bonds of the natural fibre and the composite matrix (Sepe, Bollino, Boccarusso, &Caputo, 2018), which could further improve interfacial properties of the natural fibres.
Natural fibre as reinforcement material has long been studied in published literatures, Ananas comosus, Pineapple is third most widely cultivated after banana and citrus. It is a fibre yielding plant and the fibre obtained from it is commonly known as PALF (Pine Apple Leaf Fibre). PALF comes under non-wood organic plant fibre. Pine apple leaves after harvesting remain about 40-50 leaves per shoot. It yields high quality fibre without meshing structure as in jute with high degree of crystallinity. PALF comprises of cellulose, lignin and ash. It exhibits good mechanical properties like high impact strength and tensile flexural.
Failure in reinforced composites happens due to low bonding between fibre and polymer. Alkaline treatment and saline treatment significantly improves the mechanical property of the composite. The interface between fibre and Polymer plays an important role in decreasing failure.
In this review article, various Modifications of Curaua fiber are explained based on previous researches.

MATERIAL AND METHOD:-

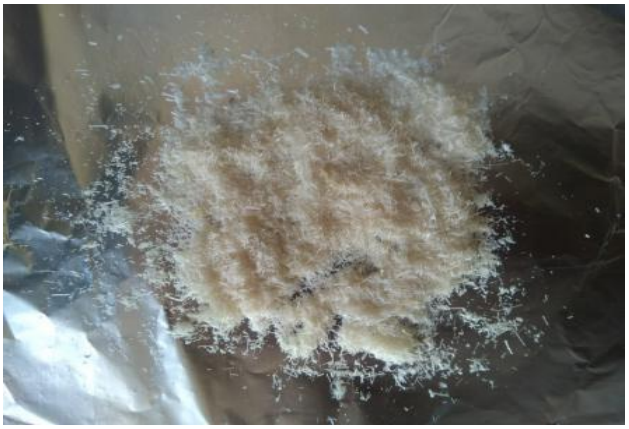
NaOH and Acetone

NaOH is used for alkali treatment and Acetone is used as solvent.

Methods in the treatment of PALF

During the chemical treatment, long fibre may agglomerate. To avoid this problem fibres need to be chopped. To ensure proper distribution of silane on fibre surface, uniform chopping is required.

Figure Chopped fibre



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Mercerization of PALF

Pineapple leaf fibre are immersed in 1M alkaline (NaOH) solution for 1 hour and washed with clean water for several times until neutral pH is reached. It is then dried in sunlight. It removes wax from the fibre and make it rough and clean.

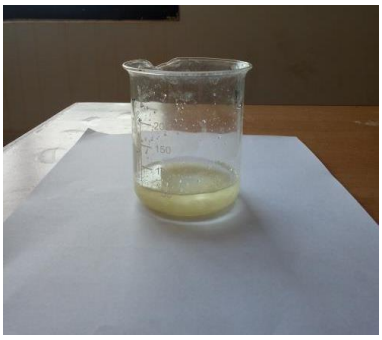


Figure Alkali treatment of fibre with NaOH

Silane treatment of PALF

The PALF were soaked in the solution containing 50 ml Acetone and silane of various amount like 0.5g, 1g, 1.5g and 2 g. It is then subjected to magnetic stirring for 3 hours at normal room temperature and dried in natural light until it is completely dried. The PALF designations are untreated PALF, Mercerized PALF, 0.5gram silane treated PALF, 1 gram silane treated PALF, 1.5gram silane treated PALF, 2gram silane treated PALF respectively.

Table - Silane Treatment

Sample No.	Weight of Silane (gm)	Conclusion
1	0	1. Mechanical stirring for 3 hours at 2. rpm : 600-1500 3. Dried in oven at 40°C for 4 hrs.
2	0.5	
3	1	
4	1.5	
5	2	

Statistical analysis –

Optical microscopy-

Diameter variation observed under optical microscope. It is observed that alkaline treatment considerably reduces fibre diameter. It indicates that wax is removed from fibre. After silane treatment, as the concentration of silane increases diameter also increases. It indicates that deposition of silane over the fibre surface

.FT-IR

Fourier-transform infrared spectroscopy (FTIR)[1] is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high-spectral-resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time.

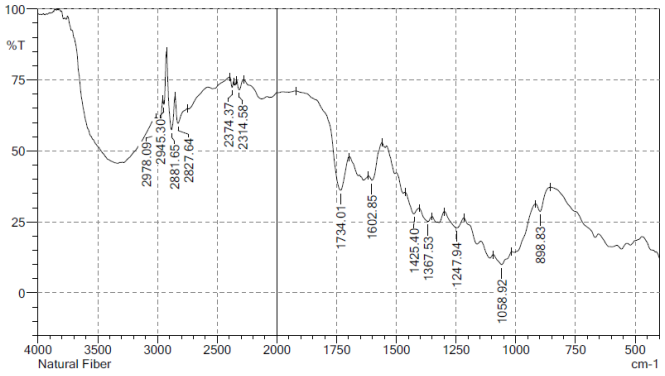
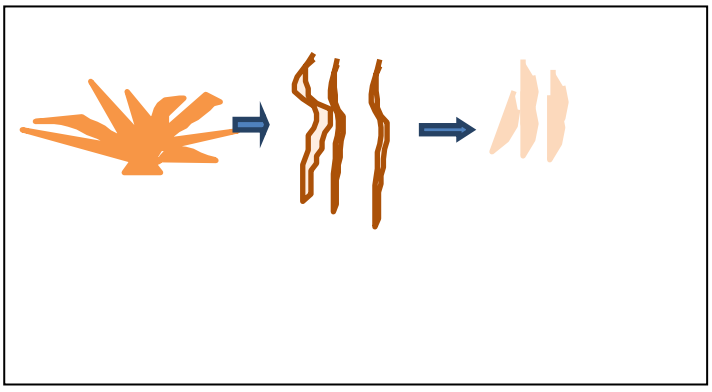


Figure Curaua Fiber FT-IR Spectra

Methods in the treatment of PALF

1. Fibre chopping



During the chemical treatment, long fibre may agglomerate. To avoid this problem fibres need to be chopped. To ensure proper distribution of silane on fibre surface, uniform chopping is required.

Fig.no. Dried Curaua fibre

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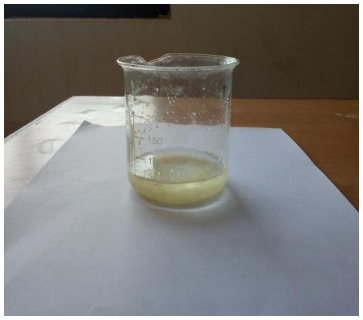
2. MERCERIZATION OF PALF

Pineapple leaf fibre are immersed in 1M alkaline (NaOH) solution for 1 hour and washed with clean water for several times until neutral pH is reached. It is then dried in sunlight. It removes wax from the fibre and make it rough and clean.



Alkali treatment of fibre with NaOH

3. Silane treatment of PALF

The PALF were soaked in the solution containing 50 ml Acetone and silane of various amount like 0.5g, 1g, 1.5g and 2 g. It is then subjected to magnetic stirring for 3 hours at normal room temperature and dried in natural light until it is completely dried. The PALF designations are untreated PALF, Mercerized PALF, 0.5 gram silane treated PALF, 1 gram silane treated PALF, 1.5 gram silane treated PALF, 2 gram silane treated PALF respectively.

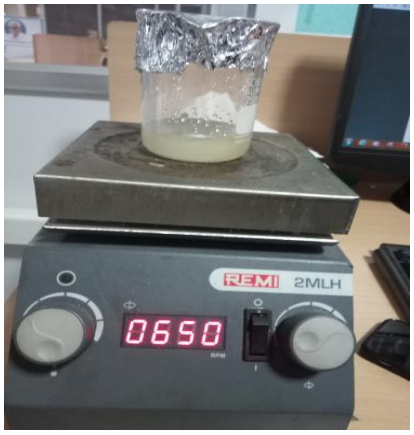
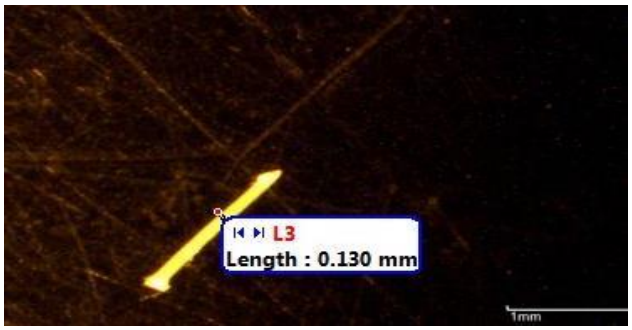


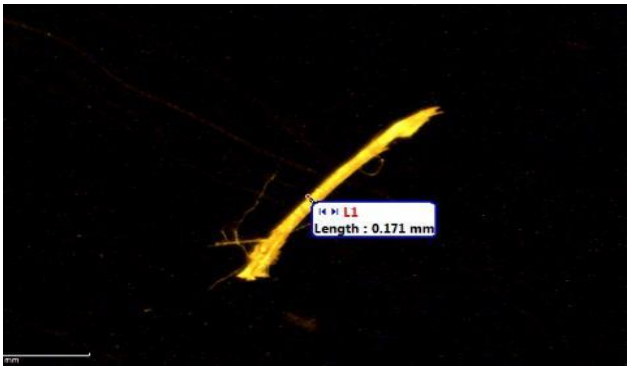
Fig. Silane treatment

Result and discussion
Statistical analysis –

1.Optical microscopy-
50 Fibres were taken from each sample and their diameter was measured under Moticam 2500 optical microscope and its readings were tabulated.

Images –
Optical Microscopy -





Fibre diameter variation, untreated (a), mercerized, 0.5, 1.0, 1.5, 2 g silane treated fibres.

*1. **Optical microscopy*** –
Diameter variation observed under optical microscope. It is observed that alkaline treatment considerably reduces fibre diameter. It indicates that wax is removed from fibre. After silane treatment, as the concentration of silane increases diameter also increases. It indicates that deposition of silane over the fibre surface

Ø Mm	UT	AT	0.5 g ST	1 g ST	1.5 g ST	2 g ST
Avg.	0.138	0.104	0.120	0.126	0.128	0.130
Stdev.	0.038	0.028	0.039	0.027	0.0301	0.0285
Max Ø	0.217	0.161	0.251	0.153	0.225	0.179
Min Ø	0.125	0.051	0.051	0.137	0.119	0.128

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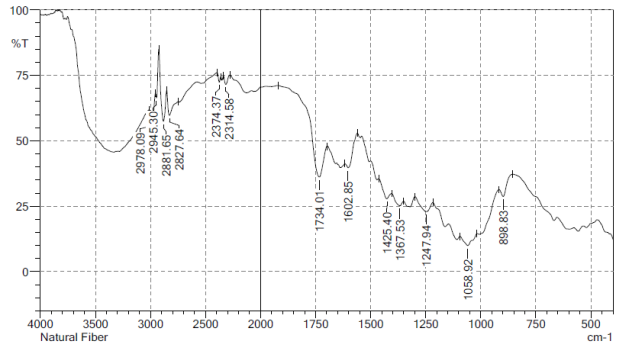
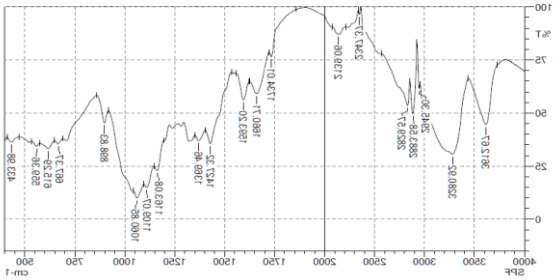
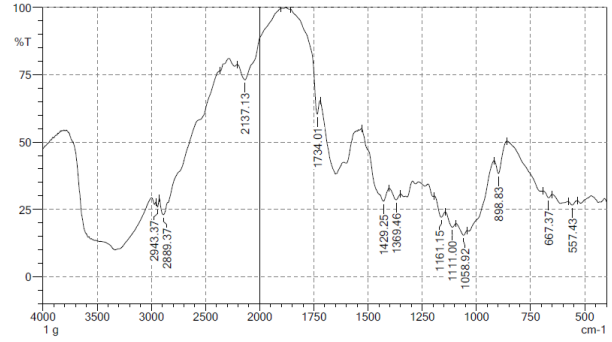
2.FT-IR



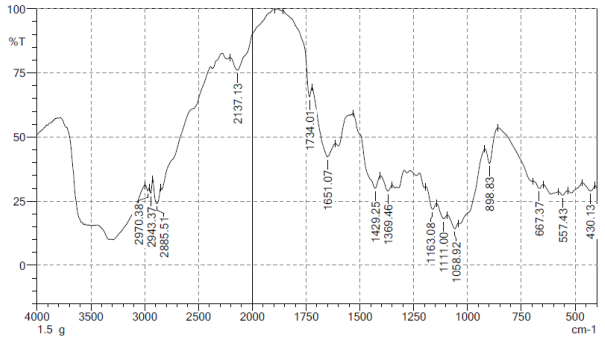
1. without alkali treatment 0.5 gm silane



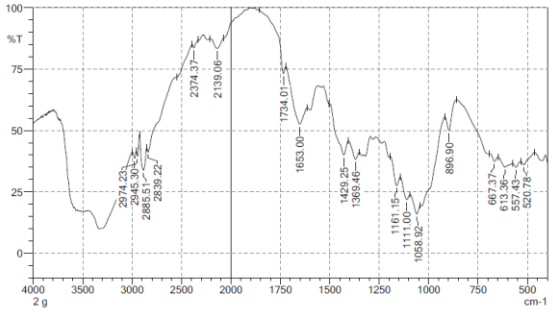
2.Alkali treated 0.5 gm silane



3.Alkali treated 1 gm silane



4.Alkali treated 1.5 gm silane



5. Alkali treated 2gm silane

FTIR Characterization

The FTIR spectra of Untreated, NaOH treated, and NaOH and VTES silane treated curaua fibers were shown in figure 1. For simplicity, the name of the fibers was labeled in short form. The NaOH treated curaua fiber was labeled as "Alkali treated". The NaOH and VTES silane treated curaua fibers were labeled as "Alkali + 0.5g VTES"; "Alkali + 1.0g VTES", "Alkali + 1.5g VTES" and "Alkali + 2.0g VTES" for 0.5g, 1.0g, 1.5g and 2.0g of VTES, respectively. From figure 1, the alkali and alkali + VTES treatment created chemical changes on the curaua fibers as indicated by the change in the FTIR spectra. The changes in the mid and far IR region clearly reflected the changes due to

chemical treatments.

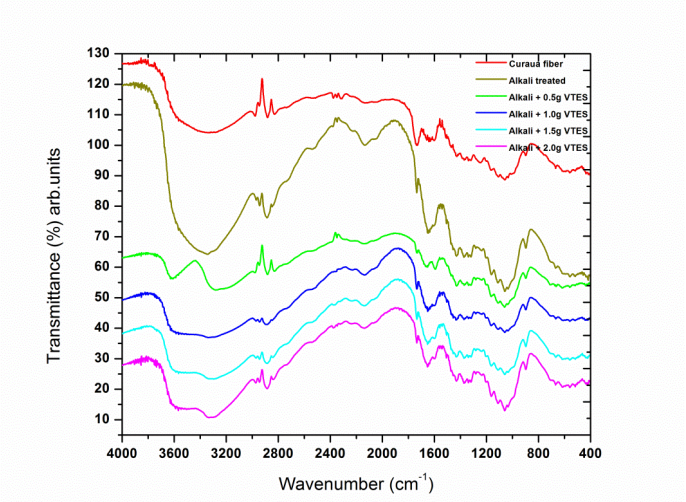


Figure 1. FTIR spectra of untreated, NaOH treated, and NaOH and silane treated curaua fiber.

On comparing the mid region of FTIR spectra (figure 2), the alkali treatment exposed more hydroxyl groups of cellulose and hemi-cellulose indicated by high intensity broad band of OH group between 3600 and 3200 cm^{-1}. On VTES treatment, the OH band of cellulose moiety decreased greatly due to condensation reaction with VTES. The ethoxy ($–O-C_2H_5$) groups of VTES undergo hydrolysis with atmospheric moisture confirmed by the two broad bands, one at 3690 cm^{-1} and another one between 3400 and 3200 cm^{-1}. The OH band at 3690 cm^{-1} represent the OH

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stretching of free OH groups and the band between the 3600 and 3200 cm^{-1} represent the OH stretching of the hydrogen-bonded OH groups. On increasing the concentration of VTES, the free OH groups and hydrogen-bonded OH groups increased due to hydrolysis of more ethoxy groups of VTES.

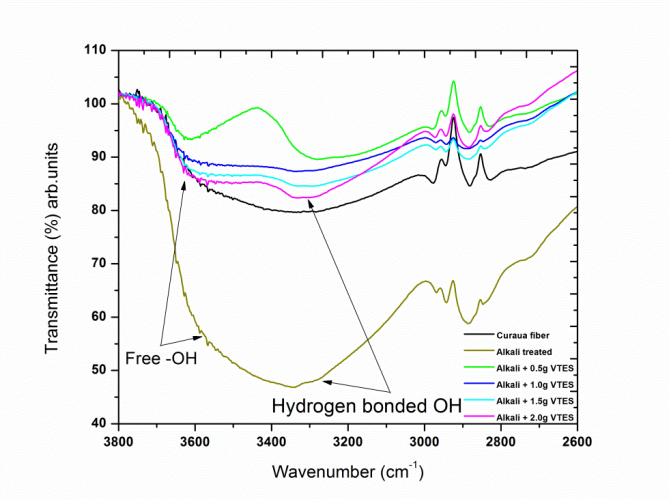

Figure 2. FTIR spectra showing OH groups of untreated, NaOH treated, and NaOH and silane treated curaua fiber.

Figure 3 showed the FTIR spectra showing silanol peaks of untreated, NaOH treated, and NaOH and silane treated curaua fiber. The concentration of vinyl, silane alkoxy and polysiloxy groups on the VTES treated curaua fiber increased on increasing the VTES concentration. In addition, on increasing the concentration of VTES from 0.5 to 2.0 g, there was multilayer adsorption of VTES confirmed by increased concentration of –Si-O-Si- formed by the condensation of hydroxy groups of VTES. The figure 4 showed the FTIR spectra showing vinyl peaks of untreated, NaOH treated, and NaOH and silane treated curaua fiber. From the figure 4, the concentration of vinyl groups also increased in support of the predication as predicted before using figure 3.

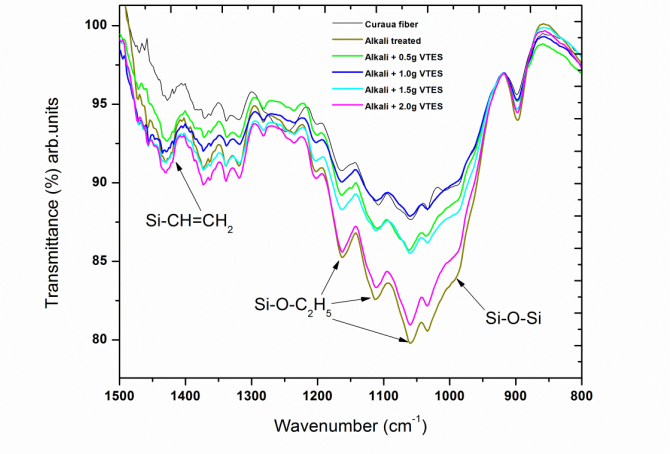

Figure 3. FTIR spectra showing silica peaks of untreated, NaOH treated, and NaOH and silane treated curaua fiber.

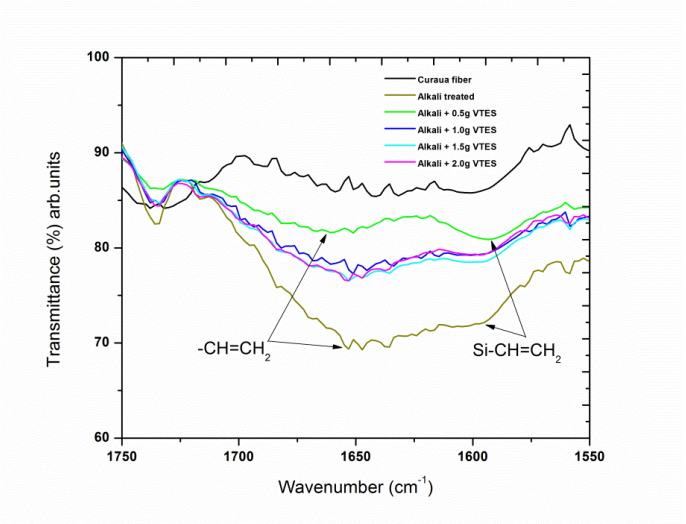

Figure 4.FTIR spectra showing vinyl peaks of untreated, NaOH treated, and NaOH and silane treated curaua fiber.

CONCLUSION

FT-IR reveals the formation of covalent si bond between fibres and silane. Microscopic observation reveals the adhesion of silane on fibre surface. Thus the results confirmed the increase in mechanical properties of fibre after the surface treatment

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